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(E76-10385) PHOTOMAPPING OF THE UNITED
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14 p HC \$3.50 CSCL 08B

N76-26616

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REPORT ON SKYLAB INVESTIGATION

NO. 498

PHOTOMAPPING OF THE UNITED STATES

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May 1976

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T-4645B

Report on Skylab Investigation No. 498

Photomapping of the United States

SUMMARY

The purpose of this experiment was to determine the feasibility of using S-190A (Multispectral Camera) and S-190B (Earth Terrain Camera) photographs taken during the NASA Skylab missions for preparing small-scale image maps. Initial data requests to NASA called for photocoverage of four widely separated areas representing various atmospheric and ground-cover conditions over the conterminous United States. However, excessive cloud interference over these designated sites eliminated them from the investigation and the Connecticut region was substituted as the experiment site. Reasonably good coverage by both camera systems was obtained for this area.

Maps compiled to date from the photos indicate that the station 5 images of the S-190A camera system can be enlarged about 11X to compile a usable black-and-white 1:250,000-scale photomap. For imagery taken on color infrared film with the S-190B camera, the largest-scale photomap that could be made with acceptable aesthetic quality was 1:100,000, requiring about 9.5X enlargement from the original negative scale. The only color photomap produced was a color infrared (false color) photomap prepared at 1:250,000 scale from four contiguous scenes using S-190A station 5 and station 2 images.

INTRODUCTION

The original objective of this research was to determine if photographs taken with the S-190A and S-190B cameras could be used to compile photomaps at scales ranging from 1:1,000,000 to 1:50,000. However, because of clouds, gaps in coverage, and the lack of good-quality imagery taken simultaneously with the S-190A and S-190B camera systems, it was impossible to find imagery covering an area larger than the standard 1° latitude by 2° longitude format of a 1:250,000-scale map.

It seems logical, however, that if acceptable photocoverage were available, it would be possible to compile photomaps at 1:1,000,000 and 1:500,000. For this reason, the research was directed toward fulfilling the more meaningful objective of determining the largest scale photomap that can be made from the imagery without serious degradation of image quality.

The Connecticut area contained the best photographic coverage that had been taken simultaneously from both camera systems. Unfortunately, panchromatic coverage from the S-190B camera was poor so that color and color infrared were used instead to produce black-and-white photomaps. Specifics of the various experiments undertaken for each of the camera systems follow.

S-190A MULTISPECTRAL SYSTEM

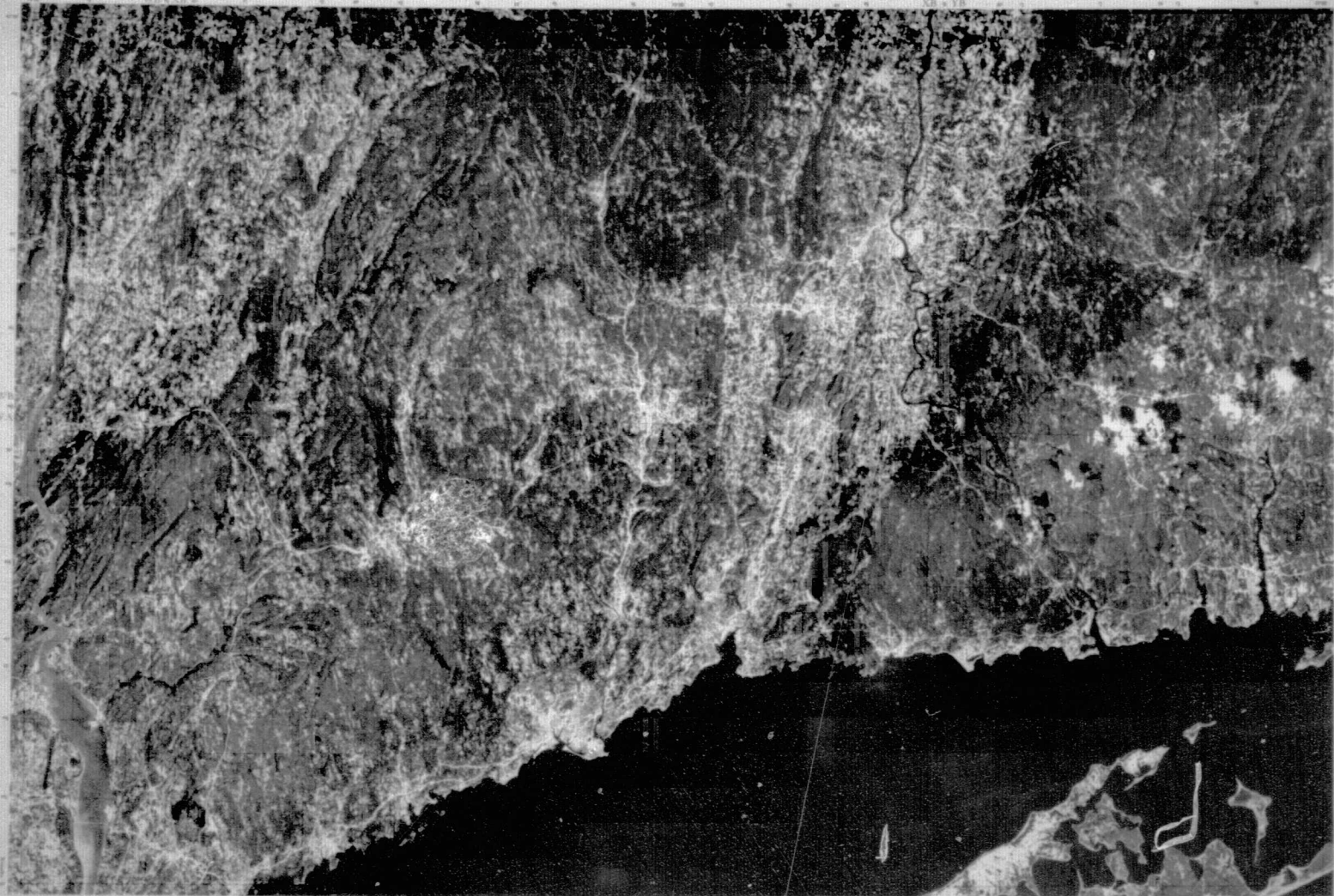
This system consisted of 6 cameras mounted and boresighted to form a camera assembly. The cameras had a focal length of 6 in (152 mm) and used 70 mm film with a 57 mm square image format. Each of the 6 cameras was identified by a station number and equipped with combinations of films and filters for various wavebands (table 1).

Table 1. S-190A multispectral camera station characteristics

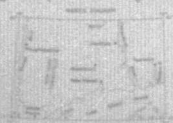
<u>Station</u>	<u>Filter bandpass (micrometres)</u>	<u>Film type</u>	<u>Est. ground resolution (metres)</u>
1	near infrared (0.7 to 0.8)	EK2424	73-79
2	near infrared (0.8 to 0.9)	EK2424	73-79
3	color infrared (0.5 to 0.88)	EK2443	73-79
4	color (0.4 to 0.7)	S0-356	40-46
5	visible red (0.6 to 0.7)	S0-022	30-38
6	visible green (0.5 to 0.6)	S0-022	40-46

Products

Hartford, Conn., 1:250,000-scale black-and-white photomap--A black-and-white photomap (fig. 1) in the 1:250,000 scale standard format (1° lat by 2° long) was mosaicked from portions of four S-190A photographs (fig. 2). These photos, which were taken with the station 5 camera at a nominal altitude of 235 nautical miles (435 km), provided a ground resolution of 30 to 38 metres, the highest resolution of the 6-camera array (table 1).



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HARTFORD, CONN. N.Y. N.J. MASS.

EXPLANATION

Figure 1 - Hartford, Conn., 1:250,000-scale black-and-white photomap.

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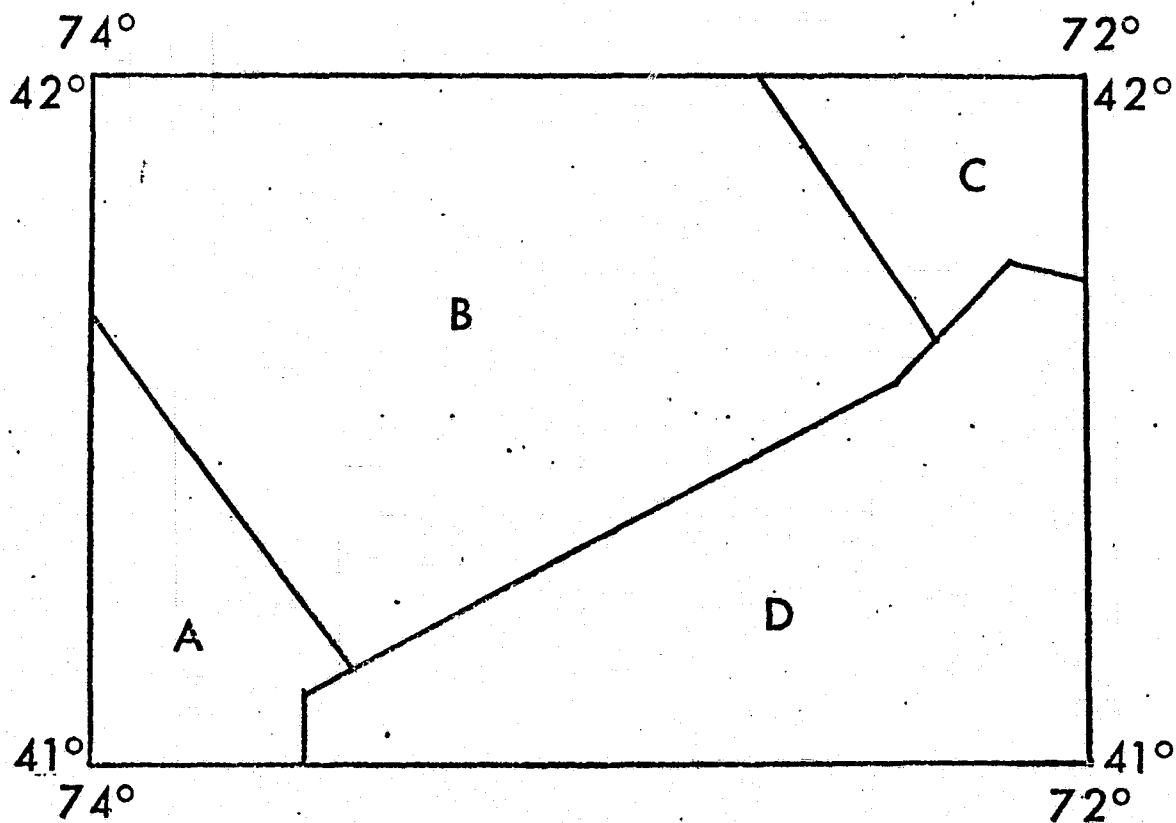


Figure 2.--Skylab S-190A camera station 5 (0.6 to 0.7 μm) coverage for Hartford, Conn., 1:250,000-scale photomap.

- A. 302-5
- B. 303-5
- C. 304-5
- D. 238-5

(All photographs taken Sept. 1973.)

Hartford, Connecticut, 1:250,000-scale, color photomap--A color-infrared photomap covering the same format as the Hartford black-and-white photomap was also prepared at 1:250,000 scale. Photographs from station 5 and station 2 were superimposed to convert the black-and-white images to a color image.

The station 5 photographs provided the best imagery for resolving cultural features and soil patterns and for analyzing land-use patterns. The photograph from station 2, filtered for haze penetration, was especially useful in determining land/water interface features. The superimposition of high-resolution panchromatic images over the haze-penetrating black-and-white infrared images offers an additional dimension to photomaps because the imagery in these combined spectral bands collectively furnishes more information than the imagery of either of the wavebands provides separately.

Accuracy Evaluation

The 1:250,000-scale, black-and-white photomap was checked for accuracy by comparing the positions of 18 well-defined features on the photomap against their ground coordinates as determined from measurements on 1:24,000-scale topographic maps. Errors in the topographic maps were considered negligible relative to the errors in the photomap.

The photomap has an RMSE of 115 m and a maximum discrepancy between mosaics of 400 m; consequently, the accuracy of the map should be within the limits of most user requirements.

S-190B EARTH TERRAIN CAMERA (ETC)

The Earth Terrain Camera (ETC) is an f/4 single-lens camera with a focal length of 18 in (457 mm), a 14.0 degree field of view, and forward motion compensation. This system provided ground coverage of approximately 4,600 mi² per frame at a nominal scale of 1:950,000. Table 2 contains information on the ETC system.

Table 2.--Earth terrain camera film characteristics

<u>Film Type</u>	<u>Wratten Filter</u>	<u>Filter Bandpass (micrometres)</u>	<u>Estimated ground resolution (metres)</u>
S0-242 (high-resolution color)	none	0.4-0.7	21
EK 3414 (high definition black and white)	12	0.5-0.7	17
EK 3443 (infrared color)	12	0.5-0.88	30
S0-131 (high resolution infrared color)	12	0.5-0.88	23

Products

Connecticut State base--A black-and-white photomap at 1:125,000 scale of the State of Connecticut was prepared from EK 3443 color infrared and S0-242 Ektachrome SL-3 photographs taken in September 1973. Conventional 1:80,000-scale photographs were used for approximately 10 percent of the area where adequate Skylab coverage was not available.

These conventional photos were transformed from perspective photos to orthophotos on the T-64 Orthophotoscope. The diagram in fig. 3 shows the photographic coverage.

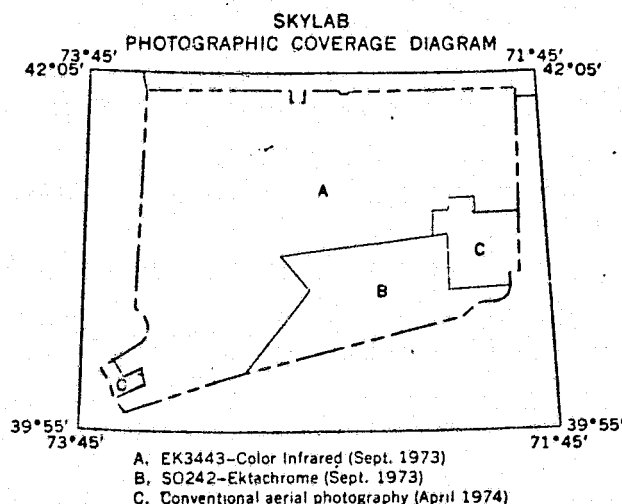


Figure 3.--Skylab photographic coverage diagram.

The Skylab images were rectified and then scaled by fitting corresponding images of preselected photoidentifiable features to plotted positions. The ground coordinates of the features were derived from measurements on existing 1:24,000-scale USGS line maps. Various laboratory techniques were used in an effort to minimize tonal differences caused by the different spectral responses of the three source films. However, these spectral response differences could not be photographically corrected to produce an esthetically pleasing product.

Hartford, Conn., 1:100,000 scale--A black-and-white photomap at 1:100,000 scale of the Hartford area (fig. 4) was prepared from a portion of a single color-infrared (EK 3443) photograph. This photomap covers about 1,100 mi² of Hartford and its surrounding area and appears to provide optimum resolution. The format is non-standard because of the orientation of the photo plus the fact that the format was expanded to take advantage of maximum area coverage.

Hartford, Conn., 1:50,000 scale--Approximately 180 mi² of the Hartford, Conn., 1:100,000-scale photomap was enlarged to 1:50,000 scale to produce another version of a Skylab photomap (fig. 5). The enlarged imagery was not fitted to a grid and only approximately scaled because the primary objective of this effort was to determine the esthetic quality of a photomap in which the imagery has been enlarged 19 times, from 1:950,000 to 1:50,000 scale.

The quality of the enlarged imagery was found to be unsuitable for photomapping. However, it may conceivably be useful for map revision.

MOSAICKING PROCEDURES

The mosaics for this study were made by using the photomechanical film montage method. An attractive feature of this method is that the use of film improves the resolution and stability of the mosaic. The

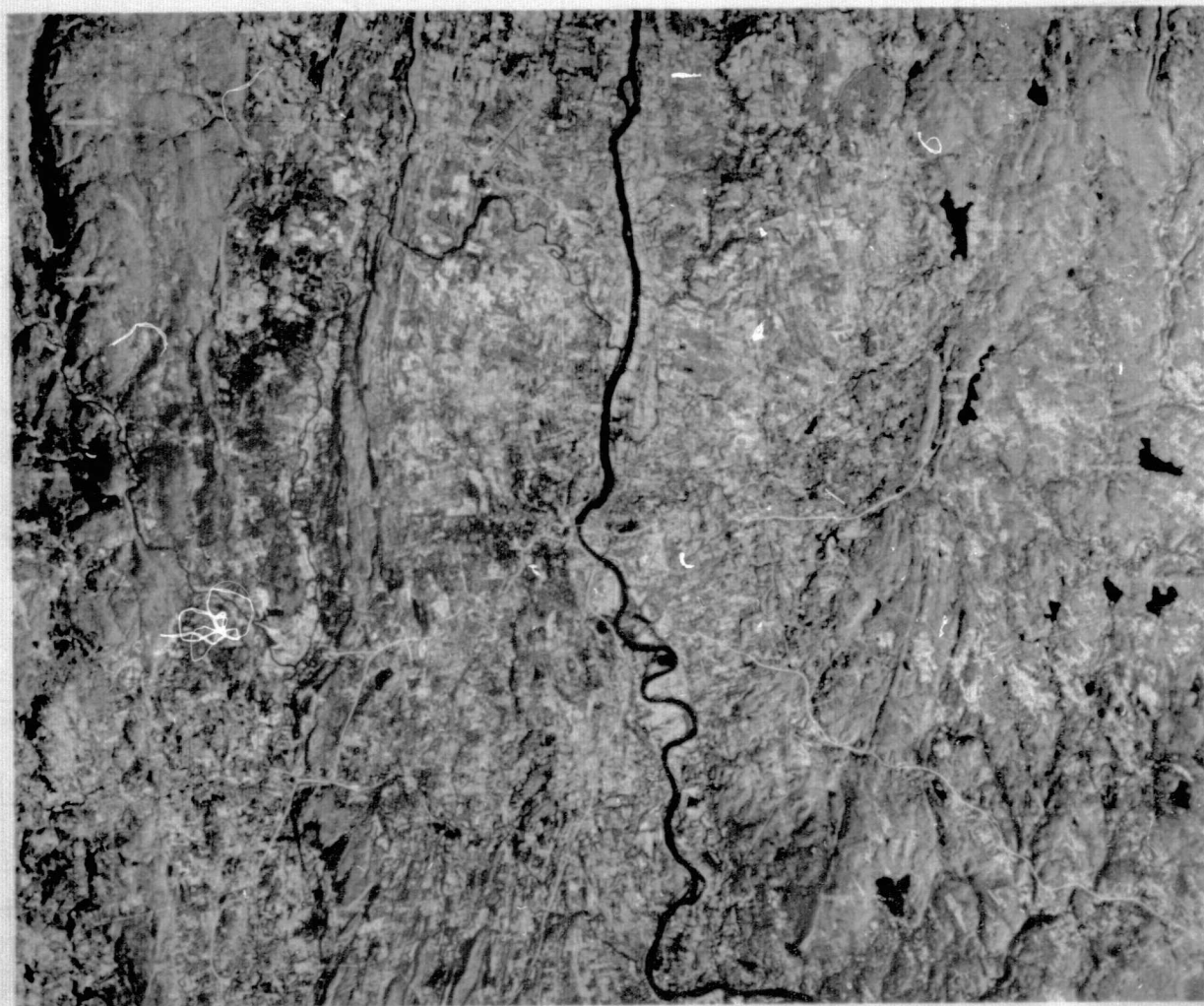


Figure 4 - Hartford, Conn., 1:100,000-
scale black-and-white photomap.

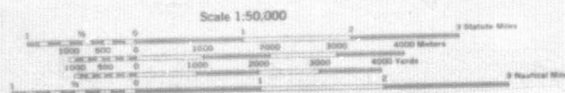


Figure 5 - Hartford, Conn., 1:50,000-scale black-and-white photomap.

mosaicking procedure (2) involves joining sets of imagery along straight lines with each joined set being printed separately, in turn, onto a mosaic film. There is a slight gap between the imagery along the join lines so that the imagery of different sets bleeds one into another and the join line is barely distinguishable.

CONCLUSIONS

This study showed that:

- Good quality photomaps can be compiled at scales ranging from 1:1,000,000 to 1:250,000 from S-190A original negatives of 1:2,860,000-scale.
- Good-quality photomaps can be compiled at scales ranging from 1:500,000 to 1:100,000 from S-190B original negatives of 1:950,000 scale. The imagery does not contain sufficient resolution for making 1:50,000-scale photomaps.
- The S-190A station 5 camera produced the highest resolution photos of the 6-camera array. It also provided the best imagery for resolving cultural features and soil patterns and analyzing land-use patterns.
- The S-190A station 2 camera was especially useful for determining land/water interface features.

- The Statement of Work for this experiment calls for a comparison between the Skylab photos and other space-related photos used for earlier photomapping projects. Previous experience with space photos has been limited primarily to photomapping with Landsat imagery. The Skylab photos have significantly superior resolution than the Landsat imagery used to date. However, an unattractive feature of the Skylab design is the lack of contiguous coverage. Standard map formats cannot be retained, but rather, the format of the map must be designed according to the availability of imagery.

REFERENCES

1. NASA, JSC, 1974, Skylab Earth Resources Data Catalog
2. R. B. McEwen and J. W. Schoonmaker, Jr., ERTS Color Image Maps, Photogrammetric Engineering, vol. 41, No. 4, April 1975, p 479-489.